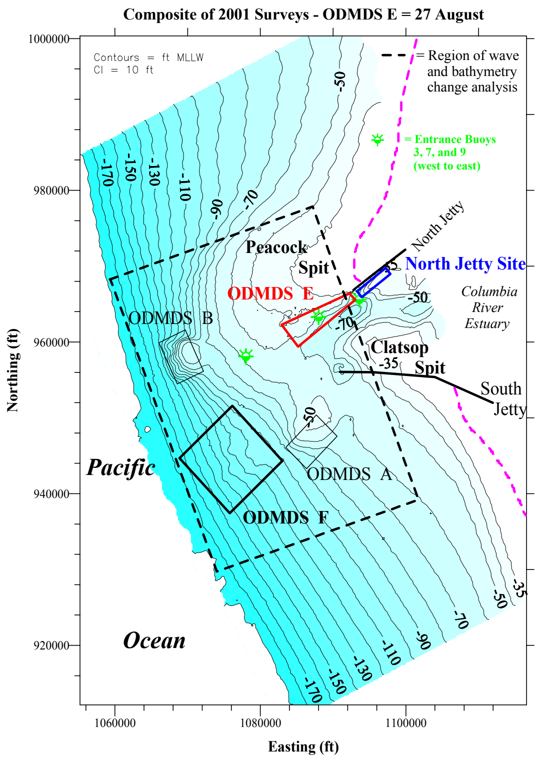
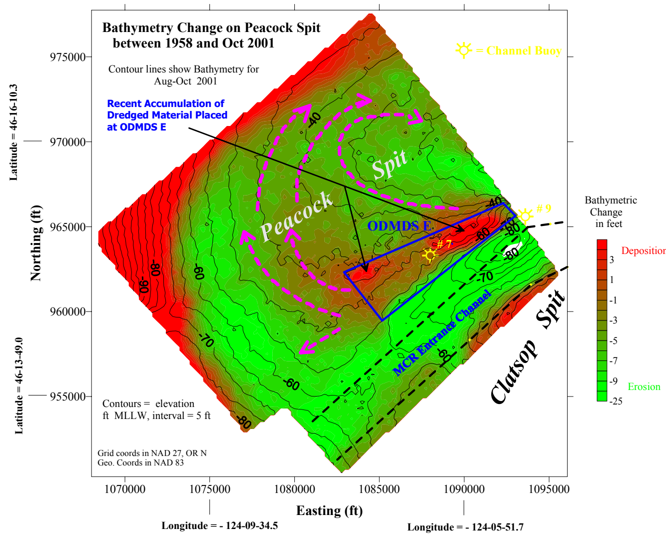
Utilization of MCR Ocean Dredged Material Disposal Sites During 2001 and Recommendations for 2002





16 January 2002

Final Report

Utilization of MCR Ocean Dredged Material Disposal Sites During 2001 and Recommendations for 2002

PURPOSE AND SUMMARY

The amount of dredged material that can be placed in an ocean dredged material disposal site (ODMDS) is limited by the site's capacity to disperse or accumulate the material without negatively affecting the environment or impairing safe navigation. As part of the management plan for an active ODMDS, the bathymetry of the site is monitored during the dredging/disposal season to determine the extent of dredged material dispersion and accumulation on the seabed. This report:

1) Describes observed bathymetric change at mouth of the Columbia River (MCR) dredged material disposal sites utilized during 2001, based on the comparison of hydrographic surveys;
2) Examines the relative usability of each disposal site based on observations made during 1997 to 2001;
3) Identifies the potential for wave-related impact of (accumulated) dredged material placed at ODMDS E during May 1997 - October 2001;
4) Presents recommendations for utilization of ODMDS E & F and the North Jetty site during 2002. In some cases, recommendations represent a departure from previous site utilization practices.

Approximately 4.1 million cy/yr of sand is dredged at the (MCR) entrance channel, based on 11 year average from 1990-2001. The dredged sand is placed at ODMDS or at sites permitted through Section 404 of the Clean Water Act (404 site). Figure 1 shows the regional bathymetry of MCR and dredged material disposal sites.

During the 2001 dredging season (June-September), 4.1 million cy of sand was dredged from the MCR navigation channel and placed in three disposal sites: The North Jetty (404 site), ODMDS E , and ODMDS F. Approximately 2.4 million cy of dredged sand was placed at ODMDS E, 498,000 cy was placed at the North Jetty site, and 1.2 million cy was placed at ODMDS F.

The North Jetty site (404 site) was first used in 1999 and is located along the southern side of the MCR north jetty, in water depths of 40–70 ft. The site now known as ODMDS E has been used since 1973. ODMDS E is located within 1/4 mile seaward of the MCR north jetty, in water depth of 45-70 ft and was officially designated as an ODMDS in 1986. ODMDS E and the North Jetty (NJ) site are considered to be within the active littoral zone of MCR and are highly dispersive: A sizable fraction of the dredged material placed at these sites is transported out of the site by waves and currents and reintroduced into the littoral system of MCR and the adjacent coast. For this reason, the NJ site and ODMDS E are used to the maximum extent possible. After being designated in 1986, ODMDS F was first used for the disposal of MCR dredged material in 1993. The site is located about 4 miles offshore (WSW) from the north jetty in water depth of 100-170 ft. Although ODMDS F is located in fairly deep water and not frequently subjected to littoral processes, the site is heavily influenced by the wave, current, and sediment interactions associated with the evolving MCR ebb tidal shoal. Sediment has been observed to be "naturally" accumulating within ODMDS F at a rate of 0.1-0.6 ft/year.

To avert excessive mounding of dredged material placed within ODMDS E during 2001, dredged material was distributed uniformly throughout the site using a series of pre-assigned disposal lanes to control the release point for each disposal event [USACE 1999a]. A specified level of dredged material accumulation was prescribed for each disposal lane for the contract dredge, depending upon pre-disposal water depth. A similar approach was also used for placement of dredged material at the NJ site and ODMDS F. The objective was to limit the vertical accumulation of dredged material placed at the disposal site. The result of using controlled placement within ODMDS E and F is shown in terms of recorded disposal locations, figures 7 and 23. It is recommended that the contractor dredge continue reporting beginning-ending coordinates for each disposal (digital compilation of coordinates sent to USACE-NWP periodically and at end of MCR dredging work), and the government dredge begin doing so – particularly when placing dredged material at ODMDS E. To fully utilize the capacity of ODMDS E and F and the NJ site during 2002, some general observations and recommendations are made.

ODMDS E: ODMDS E is the principal disposal site for MCR dredged material. Since 1997, 72% of all MCR dredged material (sand) has been placed in ODMSD E. As of October 2001, 84% of all dredged material placed within the site (since May 1997) has been dispersed by waves and currents in a north-northwesterly direction onto Peacock Spit. Less than 5% of the dredged material placed at the site has been transported southward into the MCR navigation channel. Based on monitoring conducted during 1990-2001, between 30-60% of the dredged material placed at ODMDS E is dispersed during the dredging/disposal season (June-October). The dispersion rate within the site during ensuing winter (November-May) varies between 1-1.5 million cy; and occurs regardless of the amount of dredged material placed at the site during the dredging/disposal season. Based on observed (and variable) dispersion rates, the "operational" capacity for ODMDS E ranges between 2 - 3.5 million cy/yr. Due to lower than average dispersion rates observed at ODMDS E during October 2000 – May 2001, the operational capacity of the site in May 2001 was about 2 million cy (0.5 –1 million cy lower than 1998-2000).

The close proximity of the north jetty, presence of a navigation aid (buoy #7), variable depth and complex currents & waves at the site; and conflicting site management objectives; make optimal use of ODMDS E extremely difficult. Yet, ODMDS E is presently the principal dredged material disposal site for maintaining the MCR navigation channel. Without near optimal use of ODMDS E (or designation of a new site $\geq$ capacity), the MCR entrance channel cannot be maintained. Despite the attempt to evenly place dredged material within ODMDS E during 2001, mounding of placed dredged material occurred in localized areas, and at one location exceeded 9 ft (height) with respect to the site's *baseline* (May 1997) condition. For site management purposes, the Portland District prescribes an average limiting level for dredged material accumulation at ODMDS E to be 5 ft (high). During 16-20 August, 193,000 cy of sand was "re-dredged" from the site and placed into ODMDS F. The 9 ft high mound was reduced by 4-5 ft. An additional 500,000 cy of sediment was dispersed out of ODMDS E by waves and currents during September 2001. A wave shoaling analysis indicated that as of October 2001, there was very little potential for wave amplification within or near the boundaries of ODMDS E. As waves/currents act to further disperse dredged material placed within ODMDS E, the potential for wave amplification within or near ODMDS E, due to dredged material accumulation, is expected to be eliminated.

Use of ODMDS E is highly desirable for maintaining the littoral system of Peacock Spit and locations north. Therefore, continued use of ODMDS E is strongly recommended. About 8% of the dredged material placed at ODSM E during 2001 contributed to accumulation that was greater than 5 ft high. Due to critical nature of successfully managing dredged material disposal at ODMDS E, an independent federal Review team was convened to review site management practices and make recommendations for improved future site management. Results can be found at: https://www.nwp.usace.army.mil/issues/dmd/welcome.htm. The capacity for placing dredging material within ODMDS E has been decreasing since 1999; by about 200,000 cy/year. Based on reduced site capacity and mounding issues manifest during 2001, it is recommended (at this time) that no more than 2 million cy be placed in ODMDS E during 2002. After 2002, the longterm capacity of ODMDS E is expected to be 3 million cy per year. See page 10 of this document for specific recommendations that will facilitate the avoidance of excessive mounding in 2002.

Site NJ: Much of the dredged material placed at the NJ site has abated a potentially destabilizing scour area along the southern toe of the MCR North jetty. This was the justification for using the NJ site. However, the capacity of the NJ site is difficult to fully utilize due to the site's small size, proximity of the north jetty, and limited water depth on the site's east/south side (see figure 21). It is difficult to maneuver a ship the size of a medium-class hopper dredge thru the entire site. The capacity of the NJ site to handle large volumes of dredged material is limited and requires care in operational planning and use.

As of June 2001, about 60% (900,000 cy) of the material placed in the site during 1999-2000 had remained within the site. It appears that some of the material dispersed out of the site was transported ESE, toward the north edge of the MCR channel near RM 1-2. Unless the volume of channel shoaling attributable to the NJ site becomes excessive, the value of protecting the toe of the North Jetty from destabilizing scour offsets minor channel shoaling. As of August 2001, about 80% (400,000 cy) of the material placed in the site during June-July 2001 remained within the site, and a total of 1.3 million cy was present within the NJ site when compared to the baseline condition (June 1999). Based on the vertical extent of dredged material accumulation, it is recommended that the NJ site not be used until at least 300,000 cy has been transport out of the site (there is less than 1 million cy retained within the site w.r.t June 1999). Assuming that the annual dispersion rate at the NJ site is 200,000-500,000 cy/yr (based on prior years' observed dispersion), the site may be able to receive 200,000-300,000 cy in 2002. See page 12 for additional recommendations.

ODMDS F: Although this site is fairly large and is located away from the hazards of the MCR entrance, use of ODMDS F is constrained by inbound/outbound ships using the site as a staging area for transferring MCR bar pilots to/from ocean-going vessels transiting the MCR bar. The capacity of ODMDS F is limited, and misplaced dredged material (creation of a large mound) can not be corrected, due to the depth at the site. As such, active management must be applied when planning for and placing dredged material at ODMDS F--to avoid adverse consequences.

Approximately 0.4 ft/yr (average) of "natural" deposition is occurring at the site, effectively reducing site capacity by 750,000 cy/yr. The total remaining capacity within

ODMSD F (including natural deposition for 2002) is 6 million cy. Based on the volume of "natural" deposition and projected dredged material placement, the site could be "filled" within 3 years from June 2002. This point is moot however: Due to legal statutes governing use of ODMDSs (section 103 of MPRSA), ODMDS F will no longer be available for use after May 2003. To avert excessive mounding during the 2002 disposal cycle, dredged material should be dispersed uniformly within the northern half of the site; excluding the cross-hatched area shown in figure 26. See page 14 for additional recommendations.

Collective Outlook for Present MCR Dredged Material Disposal Sites: Each of the presently available MCR dredged material disposal sites presents unique challenges for site management. Because of this, achieving the full "theoretical" capacity for each site may not be possible: Existing site capacity may run out sooner than realized.

At present, MCR dredged material disposal sites have little operational flexibility, are very difficult to manage, and collectively possess a finite capacity that may be exceeded within 1 year from June 2002. Due to legal statutes governing use of ODMDSs, the section 103 (MPRSA) portion of Site F will no longer be available for use after May 2003. It is assumed that ODMDS E and the NJ site will collectively have 1-2.5 million cy of capacity per year (for at least 10 years from present) and that both sites will be available in the future. To avoid overloading existing MCR dredged material disposal sites and prevent impedance of O&M dredging at MCR, designation of new ODMDSs having a minimum capacity of 3 million cy/yr must occur within 1 year from June 2002.

MANAGEMENT PROTOCOLS FOR ODMDS E

The site management goal for ODMDS E is to avoid modification of the site's bathymetry (via dredged material mounding) that could potentially result in wave amplification factor greater than 1.1. An amplification factor of 1.1 represents a 10% increase in wave height; with respect to the May 1997 baseline condition. With this criteria in mind, target values for allowable vertical accumulation of dredged material (with respect to the *baseline* condition of 1997) were selected based on the water depth dependent thresholds shown in table 1 [USACE 1998 and USACE 1998b]. The values shown in table 1 are based upon results obtained using the RCPWAVE model, a computer program that simulates the behavior of waves as they interact with variable bathymetry (or in this case, underwater mounds). It must be noted that results obtained using RCPWAVE can be 10-50% higher than the actual case: The RCPWAVE program overestimates how waves interact with variable bathymetry (the model is conservative). Therefore, the "Limiting Mound Height" values shown in table 1 are intended to be used only as an ODMDS management guide (a screening tool to identify thresholds for concern).

TABLE 1. Limiting dredged material mound height based on water depth.

Ambient Water Depth	Limiting (mound) Height for Dredged Material Accumulation
-50 f	4 ft
-60 ft	5 ft
-65 ft	6 ft

Based on the average water depth of ODMDS E (55 ft for the 1997 *baseline* condition), an average accumulation threshold of 5 ft was adopted for site management purposes; 4.5 ft rounded to 5 ft. Since the "limiting mound height" values in table 1 are deemed conservative, they serve as a flexible and safe operational limit for managing dredged material accumulation at ODMDS E: Localized excedance of the target values would not affect waves. Note that, the values shown in Table 1 apply to a mound feature that occupies an area of 2,000 x 2,000 ft. For small mound features that exceed the above limiting mound height values, there may be little or no wave amplification. A case by case examination of wave amplification potential may be warranted only when dredged material accumulates to levels that far exceed the "limiting mound height" and/or covers an area larger that 2,000 x 2,000 ft.

UTILIZATION OF ODMDS E DURING 2001

The management objective for ODMDS E is to fully utilize the site for the disposal of MCR dredged material, while limiting the average vertical accumulation of placed dredged material so as to avoid adversely affecting navigation at or near the site. The management target for total vertical accumulation of dredged material placed within ODMDS E is 5 ft, with respect to the site's *baseline* condition (9 May 1997) [USACE 1998b]. The preference for continued use of ODMDS E is due to:

The dispersive nature of the site - dredged material placed at ODMDS E is quickly transported to the littoral (coastal) environment of MCR. This allows for the renewal of disposal capacity at ODMDS E while using the disposal operation as a method to place or retain dredged material within the nearshore littoral environment of Washington and abate erosion of Peacock Spit and locations north. The State of Washington, thru issuance of water quality certification for MCR O&M dredging, urges Portland District to maximize use of ODMDS E, for the beneficial littoral aspects of the site.

The proximity of the site with respect to the MCR navigation channel – haul distance from MCR dredging to ODMDS E is short, making ODMDS E cost-effective to utilize and allows more dredging to be accomplished within the limited operational window at MCR.

Note that "fully utilizing" ODMDS E while not negatively affecting navigation (by limiting the accumulation of dredged material placed within the site) could be inferred as conflicted objectives. Management of conflicted objectives is problematic: This is why prudent management of ODMDS E is essential.

Bathymetry Change at ODMSD E During 2001: The *baseline* bathymetry for ODMDS E is shown in figure 2. Figure 3 shows the distribution of disposal lanes used to guide the placement of dredged material within ODMDS E during 2001. The backside of figure 3 lists the protocol for dredged material placement within ODMDS E.

Figure 4 shows the bathymetry at ODMDS E as of 31 May 2001 and documents the pre-disposal condition of ODMDS E for 2001, as well as "avoidance zones"; where dredged material accumulation was already at or near target levels and additional disposal was to be avoided. Figure 5 shows the difference between the surveys of December 2000 & May 2001 documenting winter erosion of dredged material that had been placed during 2000. About 900,000 cy of sediment was eroded from ODMDS E during the winter 2001 storm season (about 2-4 ft of erosion); much of the eroded sediment moved north of the site (toward Peacock

Spit). The level of winter erosion shown in figure 5 is considered "low" (by about 400,000 cy) when compared to "normal" trends for winter erosion at ODMDS E. Erosion at ODMDS E during winter for 1998-2000 varied between 1.2-1.5 million cy. A mild wave climate during winter 2001 and near-record low Columbia River freshet likely effected the low sediment dispersion at ODMDS E.

Figure 6 shows ODMDS E bathymetry change between the *baseline* condition (May 1997) and May 2001. Note the erosion within the eastern quarter of the site. As of May 2001, there was some dredged material remaining within the western half and center of ODMDS E from preceding years' disposal operations: Accumulation w.r.t. the *baseline* condition ranged from 1-4 ft high and contained about 1.25 million cy. This was a moderate volume of residual material and limited the capacity of ODMDS E to 2 million cy of disposal for 2001; as of the May 2001 survey. Since ODMDS E had experienced some erosion during 2001, 2.4 million cy was placed thru the dredging season. To prevent (average) vertical accumulation greater than 5 ft within ODMDS E, two restrictions were implemented for 2001 dredging/disposal:

1) No dredged material was to be placed within the "avoidance zones" of ODMDS E, until the residual material was dispersed; and
2) The erosive eastern third of the site was to be used first, to allow the rest of the site more time for dispersion.

Dredged Material Placement: During 2 June – 5 July, the government hopper dredge (*Essayons*) placed 1.29 million cy in the eastern third of ODMDS E (and 253,000 cy within the western quarter of the site during 29 July-3 Aug). During 1 July – 14 August 2001, a contractor-operated hopper dredge (*Padre Island*) placed 820,000 cy of dredged material in the western half of ODMDS E. The total volume of dredged material (sand) placed within ODMDS E during 2 June – 14 August 2001, was 2.4 million cubic yards (cy). Approximately 1.3 million cy was placed in the eastern half and 1.1 was placed in the western half of ODMDS E. No dredged material was placed within ODMDS E after 14 August.

During 12 July-13 August, an increasing level of concern was focused on the rapid accumulation of dredged material placed within the eastern quarter of ODMDS E. On 29 July, the government dredge *Essayons* stopped using the eastern area of ODMDS E and shifted to the western quarter of the site. Figure 7 shows the bathymetry of the site on 13 August, with the distribution of disposal events superimposed. Figure 8 shows the accumulation of placed dredged material that occurred within ODMDS E during 2001 (31 May-13 Aug 2001). Although 1.3 million cy of dredged material was placed within the eastern third of the site, less than 60% of the material remained on the seabed; the result was the formation of a 9-ft high mound. About 80% of the material placed within the western half of ODMDS E remained on the seabed as of 13 August; producing several mounds 3-5 ft in height.

Dredged Material Accumulation & Dispersal: The year to year management of dredged material accumulation within ODMDS E is exercised w.r.t. the baseline (9 May 1997) condition. Figure 9 shows the accumulation of dredged material that has occurred within ODMDS E during May 1997 -13 Aug 2001. The management target for vertical accumulation of dredged material within ODMDS E is 5 ft. Areas that exceeded 5 ft within ODMDS E (on 13 August) are shown by the yellow or bold contour line in figure 9, and covered 20% of the site. About 200,000 cy (or 8 % of the dredged material placed in ODMDS E during 2001) had contributed to exceedance of the 5-ft accumulation level. Had the subject 200,000 cy been placed in other areas of the site, there would have been little or no exceedance of 5 ft accumulation. Note that as of 13 August, most of the site could have received additional dredged material (0.5-1 million cy) without exceeding the 5-ft level.

Based on the desire to limit dredged material accumulation to the target level w.r.t. the site's baseline condition, the Portland District ordered the government dredge to reduce the mound within the eastern third of ODMDS E by 4-5 ft, via dredging. Although the "cut" needed to reduce the mound by 4-5 ft was estimated to be 90,000 cy, the difficulty of dredging at ODMDS E required that 193,000 cy be dredged to reach the objcetive. The "re-dredging" operation occurred on 16-20 August and the dredged material was relocated to ODMDS F. The 2001 "post-dredged/post-disposal" configuration of ODMDS E is shown in figure 10 (for 27 August).

Figure 11 shows the difference between the May 1997 & 27 August 2001 surveys and documents the total accumulation of dredged material placed within ODMDS E as of 27 August 2001, w.r.t the baseline condition. Note how the mounding was reduced within the eastern half of the site, in response to the 16-20 August dredging operation. The mounding level within the western half of the site was generally 6 ft or less (very small areas were 7 ft high). Several areas within the western half of the site had accumulated 1-2 ft of sediment during 13-27 August; in part due to dredged material disposal during 14 August and possibly from sediment moving into the site from Peacock Spit. As of 27 August, about 20% of the area within ODMDS E was covered by 5 ft or more of dredged material, w.r.t. the baseline condition.

Figure 12 shows the condition of ODMDS E on 3 October 2001, about 5 weeks after the 27 August survey. Figure 13 shows the difference between the 3 October & 31 May 2001 surveys and documents the net change (deposition and erosion) at Site E during 2001. Several statistics of interest are highlighted in figure13: A) During 27 August - 3 October there was 500,000 cy of erosion within ODMDS E, which is 23% of all material placed during 2001; and B) 60% of all dredged material placed within the site during 2001 was dispersed as of 3 October. In other words*, during the 2001 dredging-disposal season* (perhaps during the disposal process), the wave/current environment at ODMDS E had dispersed 60% of all dredged material placed at this site. The rate of "short-term" dispersion at ODMDS E during 2001 was 20% higher than any year during 1997-2000. It is noted that during fall 2001, the wave environment at MCR was the roughest in recent memory; very likely causing the high rate of dispersion at ODMDS E. Should the energetic wave environment continue thru winter 2002, much of the accumulated dredged material within ODMDS E may be dispersed by June 2002.

Fall 2001 Condition of ODMDS E: Figure 14 shows the difference between the May 1997 & 3 October 2001 surveys and documents the total accumulation of dredged material placed within ODMDS E as of 3 October 2001, w.r.t the baseline condition. As of 3 October 2001, the level of dredged material mounding in ODMDS E was 6 ft or less. About 11% of the area within ODMDS E was covered by 5 ft or more of dredged material, w.r.t. the baseline condition; a 9% reduction from the 27 August survey.

As of 3 October, only 16% (or 2.1 million cy) of all dredged material placed at ODMDS E since 1997 was observed to have accumulated on the seabed of the site. Based on observations made at ODMDS E between 1990 and 2001, the average winter (October – June) erosion rate of dredged material placed at ODMDS E is estimated to be 1-1.5 million cy.

Assuming that 1 million cy is transported out of ODMDS E during winter 2001-2002, about 1 million cy may be present within ODMDS E in June 2002 (as compared to the site's *baseline* condition). This infers a capacity of 1.5 million cy for disposal within ODMDS E during the 2002 dredging season [USACE 1998a&b], if the entire area of the site is fully utilized, localized mounding is avoided, and no erosion occurs within the site during summer 2002.

As of 3 October, the accumulation of dredged material within ODMDS E was considered to be within the management target of 5 ft. To enable comparison with previous year's results, figures 15 & 16 show the post-disposal condition of ODMDS E for 2000 and 1999, respectively. The degree of mounding within ODMDS E during October 2001 was improved from the October 2000 condition, and was no worse than October 1999. Note that ODMDS E is "filling" up; more sediment is being retained within the site each year since 1999. The rate of infilling is about 200,000 cy/yr. Assuming this trend holds true for 2001, the maximum capacity of ODMSD E for 2002 is estimated to be 2.9 million cy. To ensure that the site "flushes" itself and avoid mounding issues, it is strongly suggested at this time that ODMDS E be considered for NO more than 2 million cy (dredged material disposal) in 2002.

REGIONAL BATHYMETRY CHANGE & WAVE AMPLIFICATION AT ODMDS E

Figure 17 shows ***regional*** bathymetric changes observed at MCR during May 1997 to August 2001. During 1997-2001, moderate bathymetry change had occurred throughout the MCR region. The tops of the dredged material mounds at ODMDS A and B were eroded by 6-8 ft and much of the eroded material (sand) has been deposited near the flanks of the dredged material mounds. The crest of Peacock spit (MCR ebb tidal shoal) was eroded by 2-4 ft; with the eroded sediment appearing to have been deposited along the northern and seaward flank of the spit.

The cumulative effect of using expanded ODMDS E can be seen by the extension of the "2" ft deposition contour to the north, onto Peacock Spit. This subtle change in bathymetry occurred over a period of 5 years and indicates the effectiveness of using Site E, for the purpose of introducing dredged sand into the littoral budget north of MCR and to maintain Peacock Spit. The extension of the "0" ft deposition contour from ODMDS E south into the MCR channel may be an indication that some of the dredged material placed at Site E is being transported southward. Deposition of 2-4 ft has occurred near the seaward end of the south jetty and extends into the MCR entrance channel, in the form of a 1,500-foot wide strand oriented north-south: This feature may be an indication of sand-bypassing the south jetty to the north. There appears to be a wide tongue of (2 ft thick) deposition about 1 mile south of ODMDS B and within ODMDS F.

Overall, the MCR ebb tidal delta has experienced net erosion during 1997-2001 with deposition occurring along the toe of the ebb tidal shoal. The above MCR bathymetry changes can be thought of as a "natural" occurrence, due to the process of waves and currents acting to re-distribute MCR bottom sediment. Had ODMDS E not been used during this time, the erosion of Peacock spit would have likely been much greater.

Potential Wave Amplification at ODMDS E: During May 1997 to August 2001, about 13.4 million cy of dredged material (sand) was placed within ODMDS E. As of 27 August 2001, only 20% of all dredged material placed within ODMDS E remained within the site boundaries, however, dredged material mounding was observed to be 5-7 ft high in the southwestern quarter of the site. Collectively, the locations where accumulation exceeded 5 ft (in height) were equivalent to 2,000 x 2,000 ft in area (or 20% of the site's total area). Based on the level & extent of mounding shown in figure 11 & 17, USACE-Portland District and ERDC performed a series of wave analyses to assess the effect of mounded dredged material upon ocean waves.

The wave analysis considered ONLY the effect of waves interacting with bathymetry (the seabed); the effect of currents and wind was not included. The large "box", demarcated by a dashed black line, in figures 1 and 17 shows the region of MCR included in this wave analysis. Note that the effect of bathymetric change on the MCR ebb tidal shoal and at all ODMDS were included in the wave analysis.

RCPWAVE and STWAVE Models: The wave analysis was performed using two different computer models (RCPWAVE and STWAVE) to assess the potential impact of dredged material mounding at ODMDS E upon ocean waves travelling over Peacock Spit. The analysis examined the potential wave-related impact of accumulated dredged material that was placed at ODMDS E for two periods: During May 1997 to 27 August 2001, and for May 1997 to 3 October 2001.

The RCPWAVE model [Ebersole 1986] has been used by Portland District to simulate 2-dimensional wave shoaling since 1996. The RCPWAVE model had been used Corps-wide since 1986, is easy to use, and provides conservative estimates of shoaled wave height. In summer 2001, the Corps of Engineers-Engineering Research and Development Center (ERDC) recommended that Portland District begin using the STWAVE model [Smith et al 2001] in place of RCPWAVE; the RCPWAVE model has been shown to over-predict wave amplification due to shoaling/refraction by 10-50%. RCPWAVE is viewed as "old" technology. STWAVE accounts for nonlinear transfer of energy as waves of different period and direction interact when passing over shallow and irregular bathymetry; the RCPWAVE model does not. The STWAVE model is the present industry standard for steady-state 2-dimensional phase-averaged wave models. As such, STWAVE will now be used by the Portland District to assess wave behavior due to shoaling on irregular bathymetry.

Results from both RCPWAVE and STWAVE models are shown in figures 18 and 19, respectively. Estimates of wave amplification are associated with bathymetry change during 1997-27 August 2001, and are for waves with period of 12 seconds and approach direction of NW to WSW (295-250 deg, typical summer swell & direction). The RCPWAVE estimate indicates that mound features 5-7 ft high within ODMDS E (as shown figure 11 and 17) have the potential for amplifying waves by 20-25%. An amplification factor of 1.2 represents a 20% increase in wave height from 1997 to 2001. If "real", this result exceeds the management target for wave amplification; which has been set at 10%. Note that any wave amplification associated with dredged material accumulation at ODMDS E was predicted to be either confined within the eastern half of ODMDS E, or extend eastward toward the north jetty. No wave amplification was predicted to occur within the MCR entrance channel. Areas of potential wave amplification located away from ODMDS E are associated with the "natural" processes of erosion or deposition at MCR (see previous discussion of MCR bathymetry change).

STWAVE results indicate that mound features 5-7 ft high within ODMDS E (as shown figure 11 and 17) have the potential for amplifying waves by a maximum of 11%, but only in isolated areas. The STWAVE estimate is about 40% less than the RCPWAVE model and indicates that wave amplification at ODMDS E was nominally within the 10% amplification limit. Note the difference between the STWAVE and RCPWAVE results near ODMDS A and B: STWAVE results indicate that the wave amplification due to bathymetry change at these sites is confined to the areas of bathymetry change; RCPWAVE results indicate potential wave amplification occurs at points far (leeward) from the area of bathymetry change, which is inconsistent with reality. As of 27 August (and based on the STWAVE model), dredged material mounding at ODMDS E was not amplifying waves by more than 11%.

To determine the potential effect of dredged material mounding on waves during fall 2001/winter 2002, the STWAVE model was used to assess the 3 October 2001 bathymetry at ODMDS E (figure 14). The "average" wave period used in the model was 12 seconds (wave periods between 7-15 seconds were included) and wave direction varied from NW to SSW (295-205 deg). STWAVE results for 3 October 2001 bathymetry at ODMDS E are shown in figure 20 and indicate that wave amplification at or near ODMS E will not exceed 10%.

RECOMMENDATIONS FOR FUTURE UTILIZATION OF ODMDS E

Concentrated placement of a large volume of dredged material within a small part of ODMDS E (and within a short period of time) led to mounding (above the Corps target) within the site during 2001; mainly within the eastern third of the site. As of 13 August, 8% of the 2.4 million cy placed within the site during 2001 actually contributed to mounding $\geq$ 5 ft high, and affected 20% of the site. About 5 weeks later (3 October), after waves and currents had dispersed a significant volume of sediment out of ODMDS E, only 11% of the site was affected by mounding $\geq$ 5 ft. Similar localized mounding conditions existed for October1999 & October 2000. Avoiding the occurrence of dredged material mounding (above target levels) within ODMDS E is a matter of improving the management of less than 10% of all dredged material placed at the site. Recommendations to improve use of ODMDS E during 2002 are listed below:

1) *Measures to avoid placement of dredged material on or near areas exhibiting remnant mounding.* This was accomplished in 2001, based on lessons learned from 2000. It is recommended that the use of "avoidance zones" again be employed, if needed in 2002.

2) *Management of ODMD E should be based on the usable capacity of the site.* Areas of the site that can not be easily accessed by hopper dredges should be identified. The capacity associated with these areas should be subtracted from the site's total available capacity. This would then define the site's "operational" capacity for a given year.

3) *Uniform placement of dredged material throughout the entire site, by all dredges using the site, throughout the entire dredging season.* The contract dredge achieved satisfactory dispersal of dredged material, but the government dredge apparently did not. The concentrated placement of dredged material by the government dredge within the eastern third of the site led to mounding "issues" in 2001. Both government and contract hopper dredges could have used more of the assigned disposal areas to more uniformly place dredged material. This action by itself may have averted all mounding issues in 2001. It is recommended that all dredges using ODMDS E strive to continually

distribute dredged material within the entire assigned disposal area. Assigned disposal areas should be as large as possible to enhance distribution of placed dredged material.

4) *For advance planning purposes, ODMDS E should be considered (at this time) for no more than 2.0 million cy of dredged material disposal during 2002.* This recommendation is very conservative (underestimated) and will be verified, before commencement of the 2002 dredging-disposal season, when ODMDS E is surveyed in May or June 2002. Based on the observed Fall 2001 wave environment at MCR (intense compared to previous years) and past experience at the site, Site E may be "flushed" by June 2002 and total capacity in 2002 may be 2.5 – 3.5 million cy.

5) *The management "target" for limiting vertical accumulation of dredged material placed within the site should remain at 5 ft, w.r.t the site's baseline condition.* Because the 5-ft limit is deemed conservative (a higher value would be acceptable in reality), the "5-ft limit" serves as a safe operational limit. Concern should arise only if the level of accumulation significantly exceeds 5 ft and/or the area of accumulation exceeding 5 ft becomes greater than 2,000 x 2,000 ft. Should this occur, then the STWAVE model should be used to assess whether the area of accumulation may potentially affect waves in or near ODMDS E. In other words, it is recommended to continue using the management target (screening level, table 1) established by the more conservative RCPWAVE model for the vertical limit of dredged material accumulation; and to begin using STWAVE for assessing potential wave-related impacts of actual dredged material accumulation, if warranted

6) *The frequency of bathymetric surveys of the site should be related to the <u>volume</u> of dredged material (to be) placed within a given <u>area</u> of the site, and the <u>"lift"</u> available in which the dredged material can accumulate.* The entire area of the site need not be surveyed during each survey; only the parts of the site receiving dredged material. However, it is recommended that the entire site be surveyed at least once every month during the dredging disposal season (including pre- and post-disposal surveys).

7) *For each year during 1999-2001, about 5-8% of the dredged material placed within ODMDS E has contributed to mounding within the site (at levels greater than 5 ft). A conservative approach to minimize future mounding may be to reduce the year to year operational capacity of the site by an additional 10% (or use the site for 90% of total operational capacity).* This means that at the beginning of a given dredging/disposal season, the "conservative operational capacity" of ODMDS E would be determined as follows: "Conservative Operational Capacity" for given year = 0.9*[total annual capacity (determined from predisposal survey – baseline survey) – "avoidance zones" – non-usable capacity].

THE NORTH JETTY SITE

Figures 1 and 21 show the location of the NJ site. During 1990-1997, progressive lowering (erosion) of the seabed was occurring along the south side of the MCR north jetty, adjacent to the structure's toe. In many cases, rapid jetty deterioration has been attributed to the erosion of sediment at the structure toe. Placement of up to 1 million cy/yr of sandy dredged material at the NJ site is intended to replace sediment that has eroded from the southern toe of the north jetty, thereby protecting the structure from deterioration (caused by toe scour and related slope instability).

Bathymetry Change: Durign 1999-2000, a total of 1.55 million cy was placed within the NJ site. Figure 21 shows the bathymetric change that occurred at the NJ site between June 1999 and June 2001. During June 1999- June 2001, about 40% (650,000 cy) of all material placed within the NJ site was dispersed out of the site. It is likely that some of the dispersed sediment was transported east of the site, and deposited along the northern edge of the MCR entrance channel. As of June 2001, dredged material remaining within the NJ site was 2-6 ft thick, w.r.t. the June 1999 pre-disposal condition.

During summer 2001, the government hopper dredge *Essayons* placed 498,000 cy of dredged sand within the NJ site. Figure 22 shows the difference between the June 1999 and August 2001 surveys at the NJ site. During 1999-2001, the total volume of dredged material placed within the NJ site was 2.05 million cy. Bathymetry contours shown in figure 22 indicate the seabed elevation within the NJ site as of August 2001, after placement of dredged material at the NJ site. Note the scour area paralleling the north jetty. The objective of placing dredged material within the NJ site during 1999-2001 was to fill the scour area. Although dredged material was placed 300 ft south of the jetty (offset for reasons of navigation safety and jetty slope stability), some of the dredged sand placed in the NJ site did directly accomplish the objective of protecting the toe of the north jetty from scour.

As of August 2001, dredged material accumulation with the NJ site was 4-10 ft high, w.r.t. the June 1999 pre-disposal condition and almost all of the material placed within the NJ site during 2001 was present. It is anticipated that up to 400,000 cy will be dispersed out of the NJ site during winter 2002.

Recommendation for NJ site: Based on shoaling trends along the north edge of MCR channel, between RM 1-2, it appears that some of the dredged material placed at the NJ site may be migrating into the MCR navigation channel. Given that the present accumulation of dredged material within the NJ site is sufficient to address erosion along the north jetty toe, and the recent southward migration of sediment from the site; use of the NJ site during 2002 should be reduced to less than 300,000 cy. Dredged material should be evenly dispersed through the site, with a preference along the northern edge of the site; toward the north jetty. A pre-disposal survey of the NJ site should be obtained in spring 2002 (similar to coverage as the site's August 2001 survey) to determine how much of the material placed at the NJ site during 1999-2001 remains in 2002. If it is determined that the annual dispersion rate (fall 2001-spring 2002) is significantly less than 300,000 cy/yr, then dredged material placement at the NJ site should be reduced accordingly.

BATHYMETRY CHANGE AND DISPOSAL CAPACITY AT ODMDS F

Figures 1 and 23 show the location and bathymetry for ODMDS F. After being designated in 1986, ODMDS F was used in 1989, when 2 million cy of silty sediment (removed from Tongue Point access channel and turning basin) was placed at the site. At the time of site designation, it was assumed that there would be minimal sediment transport at ODMDS F, due to the water depth being greater than 100 ft. Within 1 year after the placement of silty sediment within ODMDS F, the 10 ft high accumulation of dredged material was covered by more than 6” of native sand, inferring nominal sediment transport (deposition) at the site. During 1993 - 1997, 6 million cy of sand (dredged from MCR) was placed within the southern half of ODMDS F. Figure 24 shows the bathymetry change that occurred at ODMDS F during1981 - 1997. The survey from1981 represents the *baseline* condition for ODMDS F. Note that between 1981 – 1997, 8 million cy of dredged material was placed within the southern half of ODMDS F yet there was a net accumulation of 11 million cy within the overall site. The apparent gain of 3 million cy of sediment within ODMDS F infers that the site may be a net depositionary environment.

Bathymetry Change & Site Constraints: To avoid potential mound-induced amplification (shoaling) of waves passing over ODMDS F, the vertical limit for mounding within ODMDS F was determined to be 15 ft. Beginning in 1997, dredged material disposal within ODMDS F was restricted to the northern half of the site. This was done to avoid placing additional material on top of the previously mounded material (10 ft high) located within the southern half of the site. Additionally, dredged material is placed uniformly (as shown by the disposal coordinates in figure 23) to avoid localized mounding.

Since 1997, an average of 640,000 cy/yr of dredged sand has been placed within the northern half of ODMDS F. Figure 25 shows the change in ODMDS F bathymetry between 1997-2001. Note that between 1997 – 2001, 3.2 million cy of dredged material was placed at ODMDS F yet there was a net accumulation of 13 million cy throughout the site. The apparent gain of 9.8 million cy of sediment within ODMDS F strongly suggests that the site may be a net depostionary environment. Figure 26 shows the overall bathymetry change at ODMDS F during 1981-2001. The “gray box” in figure 26, shows where dredged material is now placed within ODMDS F. There is considerable accumulation that has occurred within the northern half of ODMDS F. Note the 14-ft high mound located within the center of ODMDS F (cross-hatched area); mounding in this area has increased since 1997 either due to natural deposition or dredged material placement. Placement of dredged material within the cross-hatched area (figure 26) should be avoided.

Within the northern half of ODMDS F, the total capacity for dredged material disposal was estimated to be 20 million cy, w.r.t the site’s 1981 bathymetry. This was based on the average water depth at the site which, as of 1981, could accommodate 15 vertical-ft of deposition before waves are affected by shoaling and refraction. Since 1981 approximately 11 million cy of sediment has accumulated within the northern half of ODMDS F, either by dredged material disposal or natural deposition. Thus, the present capacity for the northern half of ODMDS F is 9 million cy. If the cross-hatched area shown in figure 26 is not available for dredged material disposal, then the remaining capacity of ODMDS F is reduced to 7 million cy.

Remaining Capacity: Based on surveys conducted in 1981, 1997 and 2001, it was estimated that the rate of “natural” deposition at ODMDS F is 0.4 ft/yr. A deposition rate of 0.4 ft/yr reduces available disposal capacity, within the northern half of ODMDS F, by 750,000 cy/yr. Deposition of sand at ODMDS F and adjacent areas is believed to arise from:

1) Continual seaward migration of the MCR ebb tidal shoal in response to jetty construction and MCR channel deepening (1984) – fine sand is discharged further offshore as the MCR channel has becomes deeper; and

2) An offshore wave climate that has progressively increased in severity since the early 1990's – larger waves mobilize more bottom sediment and change coastal deposition patterns.

Regardless of how the natural deposition is occurring, ODMDS F will require prudent monitoring & management to fully utilize the site's capacity and avoid excessive vertical accumulation of sediment. The following calculation identifies the capacity requirement and estimates the remaining time for utilization of ODMDS F.

*O&M dredging at MCR = 4.1 million cy/yr
*Estimated Capacity for ODMDS E (for 2002) = 2 million cy/yr
<u>*Estimated Capacity for NJ Site = 200,000 cy/yr</u>
****Volume assumed to be placed within ODMDS F = 1.9 cy/yr**
(= 4.1m/cy – 2 m/cy - 0.2 m/cy)

The time remaining for prudent utilization of ODMDS F capacity was calculated as, *total remaining capacity of ODMDS F – (volume lost due to "natural" deposition/yr + volume placed in site/yr)*time which site is used.* If 1.9 mcy/yr is placed in ODMDS F, then the remaining time (T) for which the site can be used before sediment accumulates to 15 ft is calculated as:

$$0 = 7 - (0.75 + 1.9)*T = 7 - 2.65T, \quad \text{or} \quad 2.65T = 7$$
$$T = 2.6 \text{ years …less than 3 years.}$$

Table 2 shows various estimates for the remaining time, before the disposal capacity of ODMDS F is fully used. The results shown in table 2 assume the dredged material is optimally placed within ODMDS F: Dredged material accumulates evenly on the seabed.

TABLE 2. Time remaining before for ODMDS F capacity is fully used.

Volume/year Placed in ODMDS F	Time, from June 2002 before Site Capacity is fully Utilized
1,000, 000 cy/yr	4 years
1,600,000 cy/yr	3 years
2,750,000 cy/yr	2 years
6,250,000 cy/yr	1 year

The longevity of ODMDS F is moot: Due to legal statutes governing use of ODMDSs, the section 103 (MPRSA) of ODMDS F will no longer be available for use after May 2003. If ODMDS F is no longer available for dredged material disposal, and disposal is limited to ODMDS E and the NJ site, then MCR dredging capacity may be limited to less than 2.5 million cy/yr. Within 1 year from June 2002, an alternative to ODMDS F will be required, with a minimum annual disposal capacity of at least 2 million cy/yr, assuming that ODMDS E and the NJ site can be relied upon for continued disposal of dredged material. If use of either ODMDS E or the NJ site is likely to be compromised in the future, then the alternative site for ODMDS F should have a capacity of 3 million cy/yr.

Recommendation for ODMDS F: Due to the cost effectiveness and positive "littoral benefits" of using ODMDS E and the NJ site, use of ODMDS F or other offshore sites should be minimized: Maximum use of ODMDS E and the NJ site should be achieved before ODMDS F is used. Due to legal statutes governing use of ODMDSs, the section 103 portion of ODMDS F will be available for use during the 2002 dredging/disposal season, but not thereafter. Therefor, the total capacity of ODMDS F available for the 2002 dredging/disposal season is estimated to be 6 million cy. If ODMDS F were to be used to its full remaining capacity during 2002, even distribution of placed dredged material would be essential. Dredged material should be placed uniformly within the northern half of ODMDS F, avoiding the cross-hatched area shown in figure 26.

LONGTERM BATHYMETRIC CHANGE AT ODMDS E AND PEACOCK SPIT

Construction of the MCR jetties during 1885-1917 redistributed a huge volume of sand (estimated at 600 million cy) offshore resulting in large ebb tidal deltas known as Peacock Spit and Clatsop Spit. Recent bathymetry change at ODMDS E must be placed in context to the rate and magnitude of historical change at MCR, since the jetties were built in 1885-1917. Figure 27 shows the historical change of the 40 ft depth contour at MCR, since 1889. Note the seaward advancement of the 40 ft contour in response to jetty construction (1885-1917). During 1993-2000 Peacock Spit has receded landward by 2,000 ft; as measured by the recession of the -40 ft contour. During this time, the rate of landward recession of the Peacock Spit was more than 4 times faster than during 1930-1993. Since 1997, 83% of sand dredged from the MCR channel (or 16 million cy) has been placed at ODMDS E and the North Jetty site, to reduce the rate of Peacock Spit erosion and re-introduce sand into the littoral system north of MCR.

Longterm Bathymtry Change at ODMDS E: An attempt was made to estimate the long term fate of dredged material placed at ODMDS E by comparing the present bathymetry of Peacock spit with that of 1958 (using the difference between surveys, figure 28). This comparison integrates the effects of seabed change on Peacock Spit, due to natural forces and placement of dredged material at ODMDS E. Note that since 1973, approximately 61 million cy of dredged sand has been placed at ODMDS E (as compared to 13 million since 1997).

Figure 28 shows that the seaward half of Peacock Spit, between the 50-60 ft depth countour, has eroded during 1958-2001 while areas deeper than 70 ft have experienced pronounced deposition. Essentially, the top of Peacock Spit is being sheared-off (by waves and currents) and the sediment is being deposited at the west and northwest base of the spit. Note the significant erosion immediately south of ODMDS E, along the MCR entrance channel. This is believed to be due to:

1) MCR dredging and related channel sideslope adjustment. This is a localized process.
2) Natural channel migration, toward the north. This is a regional process.

It appears that as the "natural" MCR channel migrates northward, Clatsop Spit is following suite, or vice versa: Clatsop Spit is migrating north into the "project" limits of the MCR navigation channel.

Between 1958 and 2001, it appears that dredged material placed at ODMDS E has been transported primarily north-northwest (and then east-southeast) as indicated by the pink vectors in figure 28. Dredged material placed within the eastern half of ODMDS E is believed to be transported north-northwestward onto the ridge of Peacock Spit, and ultimately toward Benson Beach. Dredged material placed within the western half of ODMDS E is believed to be transported west-northwestward onto the crest and ocean-facing slope of Peacock Spit. Dredged material that is transported onto the crest and ocean-facing slope of Peacock spit appears to be carried along the flank of the spit (parallel to the bathymetry contours) in a clockwise path, and ultimately carried back toward shore. Dredged material placed in the eastern half of ODMDS E appears to be subjected to a ***higher*** transport potential than dredged material placed in the western half of the site.

It is speculated that if dredged material had not been placed at ODMDS E (61 million cy during 1973-2000), erosion would have occurred over a much larger area of Peacock Spit than what is indicated at present. Consequently, Benson Beach (Ft. Canby State Park) would have experienced significantly higher erosion (landward recession). Based on results shown in figure 28, dredged material placed at ODMDS E does not appear to be moving south toward the navigation channel (at least in any appreciable quantity).

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